REFERENCE PACK

Best Practice Resources for Mitigation of Environmental Impacts

RURAL ROADS

USAID/West Bank and Gaza Course in Environmental Assessment and Environmentally Sound Design for Small-Scale Activities

PREPARED FOR USE IN RAMALLAH
27–30 August 2001

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USAID/West Bank and Gaza

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Rural Roads

Brief Description of the Sector

NGO support for rural roads is generally confined to the development or rehabilitation of non-asphalt roads with one or two lane-unpaved surfaces. These may be constructed to provide farmers with access to markets, or to increase community access to services such as health care or schools. In some cases NGOs may also be involved in road improvements for tourism leading to, or within, protected areas.

Road improvements can bring substantial economic and social benefits to rural communities and national economies. They may also have very significant adverse and long-term environmental impacts. This section briefly summarizes a few of the major impacts and outlines key mitigation measures in order to familiarize project developers and mangers with these issues.

Readers should consult *Roads and the Environment: A Handbook* (Tsunokawa and Hoban 1997) published by the World Bank for more comprehensive coverage of environmental, social, and related impacts and mitigation options. Practitioners are also referred to *Low-Volume Engineering Best Management Practices Field Guide* (Keller and Sherar 2001 Draft) developed for USDA, Forest Service, International Progams and USAID. Many other excellent references are listed in the Resources and References section and offer technical guidance on best practices for road improvements. Almost all of these are drawn from Keller and Sherar's bibliography

Potential Environmental Impacts of Development Programs in the Sector and Their Causes

Many of the impacts summarized below can be avoided or minimized through careful attention in the initial planning and design stage. Specifications can be incorporated in construction contracts or in road works procedures for governments or communities, and appropriate training provided in mitigation during construction, operation and maintenance. Some of the most significant impacts may include:

Soil erosion. Many adverse soil erosion impacts occur by failing to keep water off road surfaces. Roads that cross-hilly or steep terrain without following contours are especially susceptible to erosion effects, as are roads that do not have adequate side drainage to handle heavy precipitation or historical floods.

Roads may also contribute to soil erosion problems through the development of multiple tracks to avoid water and ruts. Multiple track development occurs wherever inadequate attention is paid to keeping standing water off the road surface. These effects may be particularly pronounced where roads pass through "black cotton" heavy clay soils (vertisols) or across wetlands. Abandoned roads, if not properly decommissioned can also become gulleys with severe erosion impacts.

Degradation of water quality. Detrimental effects on water quality may be associated with soil erosion and the siltation of nearby water bodies, including rivers, streams, lakes and wetlands. Siltation effects are primarily associated with agricultural development, which tends to increase significantly with expansion of new roads into previously inaccessible areas, but also with rehabilitation or upgrading of existing roads. Siltation also occurs as a secondary or indirect effect of soil erosion resulting from road improvements.

Adverse impacts on water quality may be associated with poor management of fuel and lubricants at road camps, vehicle maintenance depots and fueling areas.

Adverse effects on water quantity. Large quantities of water are needed as part of the road surface preparation and compaction process during road construction and maintenance. The impacts on water quantity may be significant where road improvements pass through arid or semi-arid areas, with potential to significantly affect aquatic species and farm production, particularly if the water used for the improvements is withdrawn during dry seasons. Roads and quarries or "borrow pits" may also create impoundments that breed mosquitoes or harbor waterborne diseases. On the other hand, this impoundments can be managed to supplement dry season water supplies for animals and people.

Altered hydrology. Roads crossing areas with high water tables or wetlands may create damming effects on surface and subsurface water flows, especially where large quantities of initial material must be added to raise the road above the land surface, and where new material must be added annually to keep the road elevated.

Under these circumstances, land on one side of the road can become much wetter than prior to the improvement, while land on the opposite side may be drier. This can adversely effect both crop production and ecosystem species composition.

Deforestation. Opening of new roads for expanded agricultural development puts adjacent forests at risk, especially where no effective forest management systems are in place. Typically, the most significant impact on forests results from the clearing of land for agriculture. However, once a road is in place, it also provides access to urban or peri-urban charcoal and fuelwood markets. The increase in access continues to have very serious implications for fuelwood resources throughout Africa. Current rates of extraction of fuelwood to meet energy demand are dramatic and clearly unsustainable. A major crisis is looming for many African countries, not only because of the depletion of fuelwood resources, but also because of the highly adverse impacts of deforestation on soils and agricultural productivity.

Damage to valuable ecosystems and habitats. International concern continues to grow for the maintenance and protection of biodiversity. Inadequate attention to biodiversity issues in road improvement can lead to the loss of species locally, including relatively undegraded forests, and to significant adverse effects on threatened or endangered species. New roads or the rehabilitation of existing roads may disrupt the integrity of plant and animal populations and permanently alter sensitive ecosystems.

The construction of new roads may also lead the introduction of exotic or non-indigenous flora and fauna that may be highly detrimental to the stability of existing plant and animal communities.

Declines in scenic quality. Construction of new roads or the realignment of existing roads may adversely affect viewsheds, which under some circumstances can lead to the loss of potential revenues associated with tourism. The cumulative effects of quarries and borrow pits over time may also cause significant loss in scenic values.

Adverse impacts on health and safety. Potential concerns include:

- *Dust and noise.* Depending on local conditions and the vicinity of houses and communities, dust and noise may be damaging to human health during construction and especially once the road is in use. The health of road construction and maintenance staff me also be adversely affected by noise and dust produced from construction, road rehabilitation and maintenance.

- *Spread of communicable diseases.* Road improvements increase communication among rural and urban populations. This in turn increases the potential for exposure to sexually transmitted diseases (including AIDS), and other communicable diseases such as tuberculosis.

- *Spread of water-borne diseases.* Where poor road design and maintenance results in poor drainage and areas of standing water, the risk of water-borne disease such as cholera or malaria increases. The same is true for standing water found in open quarries and borrow pits.

- *Traffic hazards.* Road improvements, especially those that lead to increased vehicular speed, can create significant increases in accident rates for both human and animal populations.

- *Road works hazards.* The operation of road works machinery often poses threats to the safety of both operators and laborers during both construction and road maintenance. In addition, the creation of borrow pits and quarries for road works, if not well planned can pose threats, ranging from drowning in quarry pits that have become standing water reservoirs, falling from quarry faces or less serious injuries.

Change local culture and society. The development of new roads or rehabilitation of existing roads often improve personal livelihood. Access to educational opportunities and to social services, including health care are often a key rationale for road improvements. However, socio-cultural values may also be altered and the stability of communities adversely affected through rapid exposure to social change or tourism.

Road construction and maintenance may also provide income for road workers and farmers. However, under some circumstances it has the potential of competing with farm labor during harvest and planting seasons.

Sector Program Design – Some Specific Guidance

If your organization plans to undertake rural road improvement activities, at a minimum engineering, ecological and social science expertise should be engaged and the references listed at the end of this section should be reviewed in depth.

Planning and design

For this sector it is particularly important to evaluate the initial purpose for providing transport by assessing the **need** for the road and the **purposes** it will serve. For example, if the primary purpose is transport of produce from farm to market, approximate tonnages and seasonal transport patterns need to be identified. Then costs and benefits of **potential alternatives** should be **weighed**. In some cases, transport by water, rail, bicycle or footpath may prove more practicable and desirable from an economic and environmental standpoint. Similarly, if the primary purpose is tourism, then road construction or rehabilitation should be weighed within the context of overall transportation network planning. For example, in some cases tourist roads can be re-routed to improve effects on viewsheds (following contours, avoiding straight highly visible stretches, creating more pleasing meandering tracks through woodlands, etc.). In other cases, substitution of walking trails for roads can improve visitor experience and also provide greater protection to sensitive protected area resources and ecosystems.

Planning and design suggestions include:

- Estimate future demand in order to decide on the kind and size of road to be provided. It is important to decide how many vehicles can be expected to move on the road and the approximate tonnage they will carry seasonally. This information is needed in order to design the road to last and to balance environmental sustainability with human needs.

- Assess the long-term impact on the road against the "no-action" alternative, since road improvements have many direct and indirect effects on the environment. Over a 20 or 30 year period these impacts may be cumulative in nature and highly significant, such as increased agricultural expansion or deforestation, as mentioned above. Ancillary developments can be expected, including gas stations, restaurants, hotels, markets, shops, retail stores and bars. In the case of those road improvements associated with protected areas, the long-term effects can be an increase in revenues to the protected area management systems from consumptive and non-consumptive uses. However, these must be balanced against potential damage to sensitive ecosystems and biodiversity.

- In siting roads, ensure that professional geotechnical engineering studies are done first, to avoid potentially adverse impacts on soils; to minimize possible effects on surface or subsurface water resources; to ensure correct design of drainage structures and systems, and to reduce the potential for damage from historical rains and floods.

- Require that road design follow contours and minimize viewshed impacts where feasible.

- Provide specifications for road design and maintenance that keep water off road surfaces, such as use of camber and turnout drains.

- Ensure specifications cover proper assessment of quantity of road construction material needed and their potential locations, based on quantity and quality of material at alternative sites. Prepare quarry and borrow pit management plans that identify locations, quantity to be removed from each site, and provide specific instructions for reclamation at each site. Quarries and pits often are often left unclosed because the extent of the resource was never determined and thus no plan for phased closure was prepared. Develop these plans in consultation with affected stakeholders. (**Note:** The maintenance of a rural unpaved road for 20 years or more can require extensive use of road material, and unplanned use of quarries and borrow pits can have very significant adverse cumulative effects.)

- Provide for training of equipment operators and road works crews in environmentally sound road construction and maintenance.

Operation and Maintenance

The most significant adverse environmental effects on unpaved rural roads are generally associated with poor operation and maintenance of road equipment, and inadequately trained road works personnel. Well-trained grader operators are key to proper shaping of road surfaces to direct water away from vehicle tracks and from accumulating on road surfaces. Proper management plans and well-trained road works personnel are needed to ensure that work is completed satisfactorily, following specified maintenance schedules. The same is true for maintenance of heavy equipment and training of mechanics. Often even simple maintenance procedures may not be followed, e.g., routine equipment servicing may not occur because odometers are broken or no-one is

maintaining log books on equipment use. If the equipment is not available when needed, the adverse impacts on roads can be highly detrimental and potentially very costly to correct.

Training must be provided regularly for road crews in the application of environmentally sound design principles with an emphasis on ensuring drainage structures are cleaned regularly, points of water accumulation on roads are dealt with in a timely way, road camps are well-maintained, and worker health and safety plans are being implemented.

Management plans for extraction of road materials from quarries and borrow pits must be closely supervised, as well as the procedures for reclamation prepared during the planning and design stage.

Attention needs to be paid to ensuring that crews are trained in early removal of exotic plant species, especially when roads pass near or within protected areas.

The implementation of annual environmental management plans with well-defined responsibilities and timetables for meeting mitigation and monitoring responsibilities are critical to all efforts to bring about more environmentally sound road improvement programs.

Where feasible, annual environmental management plans should be subjected to independent evaluation to determine if mitigation and monitoring results are being achieved, and to suggest corrective actions when necessary.

Decommissioning

Re-alignment of existing road is not uncommon in rural road improvement programs. When this occurs, old roads may need to blocked off with stones or other devices to prevent continuing use, and in some cases the old surface must be scraped or "ripped" to encourage revegetation.

Environmental Mitigation and Monitoring Issues

Table 1: Environmental Mitigation and Monitoring Issues for Rural Roads Projects

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Planning and Design in General (New and Existing Roads)		
Identification and weighing of alternatives		Identify known and potential areas along possible routes of ecological, archeological, paleontological, historic, religious or cultural significance and ecologically sensitive areas such as tropical forests, wetlands, and other areas of high biodiversity or threatened species (P&D)
Establishing design standards	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and paleontological resources Change local culture and society Cause soil erosion Degrade water quality and/or alter hydrology Mar scenic views Lead to injury, disease, or death of workers, and local residents Potential for excessive noise level from traffic	Chose or develop design standards for each facet of construction and related activities, e.g., road bed, road surface, drainage, erosion control, revegetation, stream crossing, sensitive areas, steep slopes, material extraction, transport and storage, construction camps, decommissioning, etc. (P&D) Provide plans to identify, protect and utilize sensitive habitats (P&D) Take into account patterns in local weather and natural phenomena, e.g., fog, flooding, earthquakes, heavy rain, mudslides, drought etc. (P&D) Include physical barriers (e.g., trees) to noise in plans where possible (P&D) Consider noise impacts when siting the route (P&D)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Planning route	Damage valuable ecosystems and habitats Damage valuable historic, religious, cultural, and palentological resources Change local culture and society Cause soil erosion Degrade water quality Alter hydrology Contribute to deforestation Mar scenic views	Have a multidisciplinary team including ideally an ecologist, geotechnical and road engineer, soil scientist, hydrologist and other relevant professionals such as archeologist or tourism specialist involved in planning new routes (P&D) Avoid routing road through sites of known paleontological, archeological, historic, religious or cultural significance (P&D) Avoid routing across agriculturally productive soils Take into account soil stability, seasonal and long-term (50 and 100 year) flooding patterns (P&D) Whenever possible site roads to follow hill contours and avoid creating slopes greater than 10 degrees Avoid gradients > 10% and long straight downhill stretches (P&D) (C) Identify sites for temporary/permanent storage of excavated material and construction materials. Where excavated material will not be reused decide how it will be disposed of or shaped (P&D) (C) Keep route a safe distance from river and stream banks Avoid environmentally sensitive areas, such as wetlands, and near protected areas or relatively undegraded forests. Explore possible "compromise" alternatives such as building a narrow, improved trail across protected area lands to provide access on foot, or bicycle/motorcycle with construction of main access roads around these areas (P&D) (C) Avoid constructing roads through forest areas, especially tropical forest, if possible. If clearing is unavoidable, protect or restore forests elsewhere within the drainage basin as close as possible to those lost (P&D) Minimize viewshed (landscape) impacts by avoiding siting roads that cut long straight paths across valleys and plains, instead hide roads beneath forest cover to minimize adverse aesthetic effects, and provide meanders where feasible (P&D) Avoid siting roads where they may disturb animal behavior or migration patterns (P&D) If sensitive areas cannot be avoided involve ecologists and engineers in designing road, construction camp, quarries and other areas. (P&D) (C)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Road surface		Stabilize the road surface with gravel/murram and other rocky surfacing material (P&D) (C) Elevate road surface (measure from base of wheel tracks) above side channel water (See Figure 1a) (P&D) (C) Clearly defined the type of road surface shape and drainage method—insloped, outsloped, or cambered/crown roadway—to be used for each section of roadway. (See Figures 1a-1e) for examples of cambered roadway) (P&D) (C)
Drainage	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	Install drainage structures during construction instead of after construction. Most erosion associated with roads occurs in the first year after construction. Delaying installation of the drainage features greatly increases the extent of erosion and damage during the first year (P&D) (C) Clearly defined the type of road surface shape and drainage method—insloped, outsloped, or crown roadway—to be used for each section of roadway. Use outside ditches control surface water when necessary, but avoid general use as they concentrate water flow and require the road to be at least a meter wider. Install frequent structures, berms or trenches, to divert water upslope of roads into stream channels (See Figure 1c) (P&D) (C) Install frequent diversion structures, such as water bars, to move water off the road frequently and minimize concentration of water (P&D) (C) Install drainage crossings to pass water from the uphill to the downhill side. If using culvert pipes, at least roughly designed them using the Rational Formula or back-calculation using Manning's Formula and high water mark prior to or during construction to determine the anticipated flow and select the correct size of pipe. Where flows are difficult to determine, use structures such as fords, rolling dips, and overflow dips that can accommodate any flow volume and are not susceptible to plugging (P&D) (C) Stabilize outlet ditches (inside and outside) with small stone riprap, and/ or vegetative barriers placed on contour to dissipate energy and to prevent the creation or enlargement of gullies (P&D) (C) Extend rurnout drains far enough to allow water to dissipate evenly into the ground (P&D) (C) Visually spot check for drainage problems, accumulation of water on water on road surfaces, immediately after first heavy rains and at the end of the rainy season and institute appropriate corrective measures (C)
Perennial and intermittent rivers and streams	Destruction of bridge by 50 or 100 year flood Damming and resultant meandering of stream which destroys neighboring sections of roadway, dwellings and/or native flora and fauna	Construct drifts rather than bridges, where feasible and cost-effective. Periodic replacement or reconstruction of damaged bridges and culverts can be costly (P&D) (C) When constructing a bridge consider using a design, such as Bailey Bridges, that are erected and dismantled so if waterway meanders, the structure can be moved to another site (P&D) (C) Try "training" rivers and streams to follow desired channels by selectively removing debris. Use a combination of hand labor, and small machinery. Careful and selective bulldozing may be feasible in some cases. However, dozer tracks can easily expose soil to erosion and do more harm than good (P&D) (C)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Wetlands	Degrade wetland damaging the valuable ecosystems and habitats Alter hydrology	Avoid routing through these areas (see "Planning route" above for additional guidance) (P&D) Minimize cuts and/or fills and compensate for impact by protecting other wetlands (P&D) (C) Take special precautions to prevent release/dumping of debris, oil, fuel, sand cement, and similar harmful materials (C)
Sloped areas and raised roads	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	Stabilize slopes by planting vegetation. Work with agronomists to identify native species with the best erosion control properties, root strength, site adaptability, and other socially useful properties. Set up nurseries in project areas to supply necessary plants. Do not use non-native plants. Use soil stabilizing chemicals or geotextiles (fabrics) where feasible and appropriate (P&D) (C) Minimize use of vertical road cuts even though they are easier to construct, and require less space than flatter slopes. The majority of road cuts should have no more than a ¾:1 to 1:1 slope to promote plant growth. Vertical cuts are acceptable in rocky material and in well-cemented soils (P&D) (C) Install drainage ditches or berms on up-hill slope to divert water away from road and into streams (See Figure 1c) (P&D) (C) Install drainage turnouts at more frequent intervals and check dams to reduce ditch erosion (P&D) (C) If possible, use higher grade gravel that much less prone to erosion (P&D) (C) If very steep sections cannot be avoided provide soil stabilizers or surface with asphalt/concrete (P&D) (C)
Construction contracts	All	Select or develop guidelines and procedures to be applied to each facet of road construction and incorporate them into contracts with construction companies, e.g., site clearing; bed and surface construction; drainage; fuel and materials usage; quarry site management; construction camp and work site operating procedures, including worker safety Include incentives for adhering to guidelines and penalties for violating them
Maintenance agreements	All	Finalize maintenance agreements with local communities **before** beginning construction. All parties must clearly understand and be committed to the terms of the agreement such as who will do what work, when, how frequently, for what compensation, and within what limits
Planning and Design—Existing Roads		
All projects		Use a "clean slate" approach, i.e. consider realigning all minimal/informal roads to follow contours and avoid sensitive areas (P&D)
Road surface is below grade of surrounding road	Cause soil erosion Degrade water quality; Alter hydrology	Raise road surface with stable fill material. Grade with inslope, outslope or cambered shape. Install sufficient cross-drains, ditches and settling ponds (Figure 1a)(P&D) (C) (O&M)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Road is steeply sloped and eroding	Cause soil erosion Degrade water quality; Alter hydrology	Consider realigning the road section so that it conforms to preferred design parameters described above. Decommission original road sections after realignment (see "Decommissioning" below) (P&D) (C) (O&M)
Deteriorated road surface	Cause erosion Damage vehicles	Determine cause of deterioration. If heavy use, either find a means of reducing traffic or upgrade road to more durable surface (gravel, asphalt, or concrete) (Figure 1e) (P&D) (C) (O&M)
Drivers drive at excessively high speeds	Cause injury and death of people and animals	Realign road sections to meander, curving roads deter speeding (P&D)
Sections have multiple tracks/off-road driving	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	Generally caused by either muddy/flooded roadway or highly deteriorated roadway. Maintain or upgrade road so road section no longer floods or becomes muddy (P&D) (O&M)
Road section must be realigned		Remove surface if necessary and loosen soil of previous track (to accelerate regeneration of vegetation). Block access with rocks, branches, roadblocks and signs. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment. Wider roads may require active planting and reseeding (C) (O&M)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Construction		
Construction camp and crew	Damage local habitat, compact soil and create erosion via building and occupation of construction camp Contaminate surface water and spread disease via solid waste and feces generated by camp Spread communicable diseases including malaria, tuberculosis, and HIV/AIDS via construction crew who come from outside the region. Introduce alcohol or other socially destructive substances via construction crew Adversely effect local fauna and flora (especially game and fuelwood) via poaching and collection by construction crews	Explore off-site accommodation for crew (P&D) (C) Keep camp size to a minimum. Require that crew preserve as much vegetation as possible, e.g., by creating defined foot paths (P&D) (C) Provide potable water for crew Provide temporary sanitation on site, e.g., VIP latrine (assuming the water table is low enough and soil and geology of appropriate composition) (Also consult "Water Supply and Sanitation" in this volume). Where this is not possible instruct road crews to employ soil mining (digging a pit for human waste and covering with soil immediately after use) (P&D) (C) Use local or regional labor, if possible. Provide hygiene and public health training to road crews, including transmission and prevention of HIV/AIDS and other sexually transmitted diseases (P&D) (C) Collect all solid waste (metal, glass, and burnable materials) from all work and living areas. Dispose of waste in local dump or landfill. If this is not possible, sell recyclables for reuse/recycling, place organic wastes in well-screened waste pits, covering with soil weekly, bury the remainder (excluding toxic materials). (Also consult the "Management of solid waste from residential, commercial and industrial facilities" in this volume) Set guidelines prohibiting poaching and collection of plants/wood with meaningful consequences for violation such as termination of employment. Provide adequate quantities and good quality food and cooking fuel (C) Restore site through revegetation and similar measures after camp is broken down (C) Test grade driver's ability to follow grade, slope, and contour design standards. Train if necessary (P&D) (C) Test bulldozer and other equipment operators' ability to properly maintain drainage structures. Train if necessary (P&D) (C) Test road crew's ability to keep roads clear of vegetation with least adverse environmental impacts. Train if necessary (P&D) (C) Provide workers with appropriate safety equipment, e.g., ear plugs or head gear to mute noise from very loud equipment; masks for workers exposed to large amounts of dust; safety glasses for workers doing jobs that may generate sharp projectiles

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Use of heavy equipment and hazardous materials	Cause erosion due to machinery tracks, damage to roads, stream banks, etc Compact soil, changing surface and groundwater flows and adversely affecting future use for agriculture Contaminate ground or surface water when: (1) machinery repairs result in spill or dumping of hydraulic oil, motor oil or other harmful mechanical fluids; and (2) when hazardous construction materials are spilled or dumped Put workers at risk from exposure to hazardous materials Generate excessive noise levels that impact both the surrounding community as well as health and safety of workers	Minimize use of heavy machinery (P&D) (C) Set protocols for vehicle maintenance such as requiring that repairs and fueling occur elsewhere or over impervious surface such as plastic sheeting. Prevent dumping of hazardous materials. Capture leaks or spills with drop cloths or wood shavings. Burn waste oil that is not reusable/readily recyclable, do not contain heavy metals and are flammable. Prohibit use of waste oil as cooking fuel (P&D) (C) Investigate and use less toxic alternative products (P&D) (C) Prevent fuel tank leaks by a) monitoring and cross-checking fuel levels deliveries and use, b) checking pipes and joints for leaks, c) tightening generator fuel lines, d) preventing over-filling of main storage and vehicle tanks (C) Install and maintain mufflers on construction equipment Ensure workers follow proper health and safety guidelines for wearing hearing protection devices

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Materials extraction: Quarrying, logging	Damage aquatic ecosystems through erosion and siltation Harm terrestrial ecosystems via harvesting of timber or other natural products Spread vector-borne diseases when stagnant water accumulates in active or abandoned quarries or borrow pits and breeds insect vectors	Identify the most environmentally sound source of materials that is within budget (P&D) (O&M) Use material from local road cuts first, it produces a fairly durable aggregate for both surface stabilization and erosion control and is very cost effective (P&D) (C) Develop logging, quarrying and borrowing plans that take into account cumulative effects (P&D) Take photos of site before initiating excavation, so that restoration can match original site characteristics as much as possible (C) (O&M) Site quarries and gravel pits so that they are not visible to travelers on the roads (P&D) (C) (O&M) Monitor adherence to plans and impacts of extraction practices. Modify as necessary (C) (O&M) Decommission/restore area so it is suitable for sustainable use after extraction is completed (C) Install drainage structures to direct water away from pit (C) (O&M) Implement safety protocols to minimize risks from falling rock or debris, collapsing quarry walls, or accidental falls from cliffs (P&D) (C) (O&M) Develop specific procedures for storing topsoil, and for phased closure and reshaping and restoration when extraction has been completed. Include plans for segregating gravel and quarry materials by quality and grade for possible future uses. Where appropriate, include reseeding or revegetation to reduce soil erosion, prevent gulleying and minimize visual impacts (P&D) (C) (O&M) Discuss with local community the option of retaining quarry pits as water collection ponds to water cattle, irrigating crops or similar uses. Issues of disease transmission and prohibiting use for drinking, bathing, and clothes washing should be highlighted (P&D) (C) (O&M)
Storing materials	Deplete water resources Damage valuable ecosystems and habitats	Pre-wet gravel when water is more available (i.e., not during dry season) and store gravel in a way that will keep it wet, e.g., covered with plastic sheeting (P&D) (C) Avoid using sensitive areas as storage sites or sites that drain directly into a sensitive area (P&D) (C)

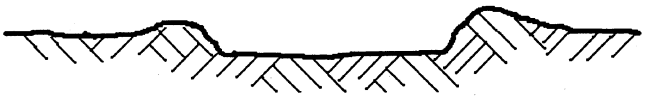
Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Site clearing and/or leveling	Damage or destroy sensitive terrestrial ecosystems Produce areas of bare soil which cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems Creation of local dust problems	Minimize disturbance of native flora during construction. Minimize the amount of clearing. Clear small areas for active work one at a time (P&D) (C) Avoid use of herbicides. Any use should follow health and safety procedures to protect people and the environment. At a minimum, herbicides should be used according to manufactures specifications (C) Remove without destroying large plants and turf where possible and preserve for replanting in temporary nurseries (P&D) (C) Carry out earth moving and removal of vegetation only during dry periods. Store topsoil for respreading. If vegetation must be removed during wet periods, disturb ground only just before actual construction (P&D) (C) Install temporary erosion control features when permanent ones will be delayed. Use erosion control measures such as hay bales, berms, straw or fabric barriers (C) Revegetate with recovered plants and other appropriate local flora immediately after equipment is removed from a section of the site (C) Periodically water down or lightly oil temporary roads.
Excavation	Cause erosion, siltation, changes in natural water flow, and/or damage to aquatic ecosystems when excavated soil is piled inappropriately Expose inhabitants and crew to risk of falls and injuries in excavation pits Deprive down-gradient populations and ecosystems of water if upper regions of aquifer are blocked	Cover pile with plastic sheeting, prevent run-off with hay bales, or similar measures (P&D) (C) Place fence around excavation (P&D) (C) Investigate shallower excavation/no excavation alternatives (P&D) Have construction crews and supervisors be alert for buried historic, religious, and cultural objects and provide them with procedures to follow if such objects are discovered. Provide incentives for recovery of objects and disincentives for their destruction (P&D) (C) Ensure excavation is accompanied by well engineered drainage (P&D) (C)
Filling	Block water courses when fill is inappropriately placed Destroy valuable ecosystems when fill is inappropriately placed Cause later land subsidence or landslides when fill is inappropriately placed, causing injuries and damages.	Do not fill the flow-line of a watershed. Even in arid areas, occasional rains may create strong water flows in channels. A culvert may not supply adequate capacity for rare high volume events (P&D) Design so that filling will not be necessary. Transplant as much vegetation and turf as possible (P&D) (C) Use good engineering practices. (e.g., Do not use soil alone. First lay a bed of rock and gravel) (See Fig 1d) (P&D) (C)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Cutting & filling	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	Test grade driver's ability to follow grade, slope, and contour design standards. Train if necessary (P&D) (C)
Compacting	Deplete freshwater resources	Water the road immediately prior to compaction to strengthen the road surface. (Otherwise traffic will soon beat back the road surface to pre-bladed condition) (P&D) (C) When possible, delay compaction activities until the beginning of the wet season or when water becomes more available (P&D) (C)
Blasting	Cause soil erosion Degrade water quality Alter hydrology Damage valuable ecosystems and habitats	Minimize blasting (P&D) (C) Take safety precautions to protect workers and others from being injured by flying or falling rock and avalanches (P&D) (C)
Design verification		Conduct independent inspection of work periodically to see that it conforms to original plan and design specifications. Provide incentives and disincentives to ensure conformance (C) Drive roads after moderate rains to identify areas that collect or gully water. Mark and redesign/rehabilitate as necessary (C)
Operation and Maintenance		
Road maintenance	Create gulleys and standing pools Create mud holes, potholes Breed disease vectors in settling basins and retention ponds Degradation of physical noise barriers Excessive dust	Monitor and maintain drainage structures and ditches including culverts. Clean-out culverts and side channels/runouts when they begin to fill with sediment and lose their effectiveness (O&M) Fill mud holes and potholes with good quality gravel; remove downed trees, and limbs obscuring roadways (O&M) Use water from settling basins and retention ponds for road maintenance (O&M) Maintain physical barriers used as noise abatement (O&M) Periodically water or lightly oil roadways (O&M) Maintain roadside plantings to prevent dust (O&M)
Construction camp and crew	(See "Construction camp and crew" above)	(See "Construction camp and crew" above)

Activity	Impact *The activity may. . .*	Mitigation Note: Mitigations apply to specified project phase: *Planning and design (P&D), Construction (C), or Operation and Maintenance (O&M)*
Use and maintenance of equipment	(See "Use of heavy equipment and hazardous materials" above)	(See "Use of heavy equipment and hazardous materials" above) Install concrete pads, drains and oil/water separators in areas where vehicle and equipment maintenance and fueling will occur regularly
Decommissioning		
Decommissioning	Cause soil erosion Degrade water quality Damage valuable ecosystems and habitats	Break up old road surface and soil. Remove and dispose of surfacing material (e.g. asphalt) if necessary and loosen soil of previous track (to accelerate regeneration of vegetation) Reshape eroded or culled surfaces so that water will no longer follow the course of the roadway (See Fig. 1e) Revegetate as needed. Narrow tracks will usually revegetate naturally with no noticeable scars or impact on the environment, wider roads may require active planting and reseeding (O&M) Block access with rocks, branches, roadblocks and signs.

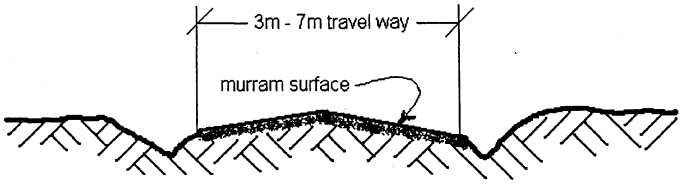
Figure 1a

Typical Existing Road Section



Wear and grading or erosion has lowered road surface below surrounding landscape; road now collects rain runoff and is wetter than surroundings

Typical Proposed Road Cross Section

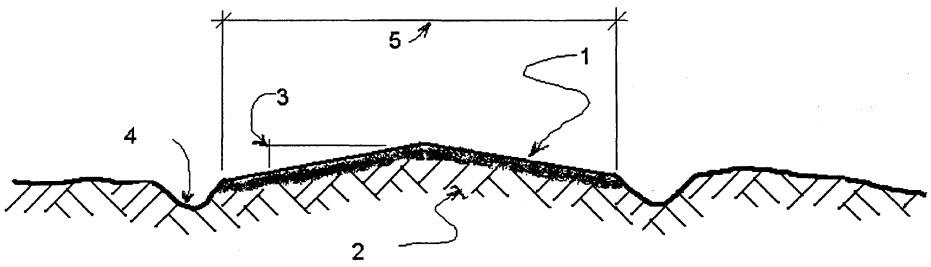


Side Drain Ditch - depth of ditch will vary along the length of the run between turnout or outlet

Note: Max Camber Slope:
1 in 40 to 1 in 33
(2.5%) (3%)

Figure 1b

Cross Section of a Gravel Road



KEY
1 - Layer of murram; thickness of murram layer depends on soil type at site
2 - Subgrade
3 - Cross-slope 1 in 33 to 1 in 40
(3%) (2.5%)
4 - Side drain ditches
5 - Traveled way; width depends on the class of road

Figure 1c

Drainage in Hilly Roads Cross Section

Key
1 - Water catchment ditches/drains
2 - Side ditch drain
3 - Traveled way

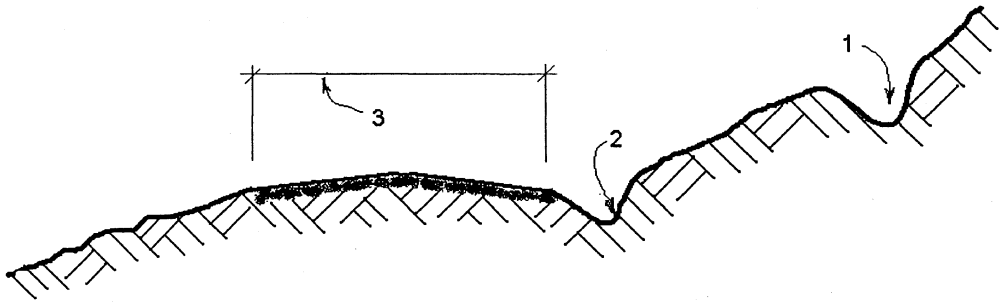
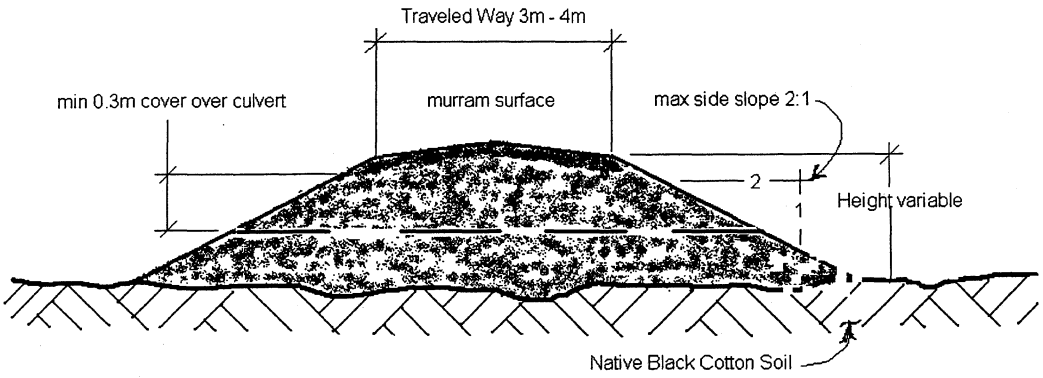


Figure 1d

Raised Road Embankment

Typical propsed Black Cotton fill cross section

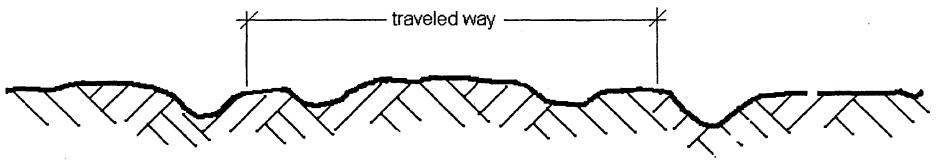


Note: Reapply surface vegetation and surface soil to new fill slopes to aid in revegetation

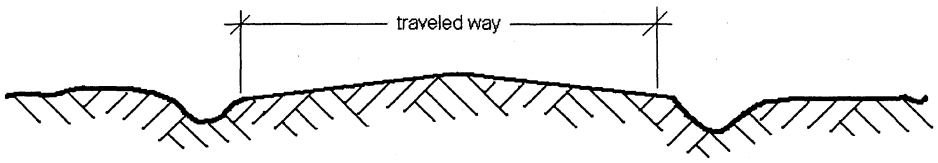
Figure 1e

Longitudinal Ruts Correction

Typical road cross section with longitudinal ruts caused by vehicle tyres



Typical road cross section after filling up the longitudinal ruts by reshaping the road



REFERENCES AND USEFUL RESOURCES

Tsunokawa, Koji and Christopher Hoban (Eds.) (1997) *Roads and the Environment: A Handbook.* World Bank Technical Paper No. 376. World Bank, Washington, D.C.
http://www.worldbank.org/transport/publicat/reh/toc.htm or http://www-wds.worldbank.org/pdf_content/000178830981019041614l9/multi_page.pdf
Readers will likely want to focus on part II that details specific environmental, social, and other impacts.

The World Bank Roads and Highway Group http://www.worldbank.org/transport/r&h_over.htm
Links to tools and literature covering many dimensions of road construction including planning, financing, institutional management, safety, construction and maintenance, environment, and tolls among others.

Tanzania National Parks, et al. (2001) *TANAPA Environmental Management Plans Guidelines for Road Improvements (Working Draft).* March 23, 2001.

Best Management Practices- General

Michigan Department of Natural Resources. 1994. Water Quality Management Practices on Forest Lands.

Minnesota Department of Natural Resources, Division of Forestry. 1994. Visual Quality Best Management Practices for Forest Management in Minnesota.

Montana Department of State Lands. 1992. Montana Forestry Best Management Practices.

Vermont Department of Forests, Parks and Recreation. 1987. Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont.

Wisconsin Department of Natural Resources. 1995. Wisconsin's Forestry Best Management Practices for Water Quality-Field Manual for Loggers, Landowners and Land Managers. Publication No. FR093.

Roads Planning and Special Applications

Keller, G; Bauer, G.; Aldana, M. 1995. Minimum Impact Rural Roads (Caminos Rurales Con Impactos Minimos). Training Manual written in Spanish for U.S.D.A., Forest Service, International Programs, USAID, and Programa de Caminos Rurales, Guatemala City, Guatemala.

Dykstra, D.; Heinrich, R. 1996. FAO Model Code of Forest Harvesting Practice, Food and Agriculture Organization of the United Nations, Rome.

PIARC World Roads Association. 1995. Natural Disaster Reduction for Roads, Comprehensive Report 72.01B

Basic Engineering Considerations for Low-Volume Roads

American Association of State Highway Transportation Officials. 1994. Local roads and streets. In: A policy on geometric design of highways and street. Ch. 5. [Online]. Available for purchase: http://www.aashto.org [2000, July 30]. (Covers the design standards for local road and street design.)

Australian Road Research Board Limited. 1993. Unsealed Roads Manual- Guidelines to Good Practice, Vermont South Victoria, Australia

California State Parks. 2001. Heavy Equipment Operators Guide to Road Rehabilitation. North Coast Redwoods District, Eureka, California (a Field Guide to Road Closure and Obliteration).

Charles. R. 1997. Design of Low Volume Low Cost Roads. UWI Public Information Series/Roads, Volume 1. Dept of Civil Engineering, University of West Indes, West Indes

Moll, J.E. 1996. A guide for road closure and obliteration in the Forest Service. U.S. Department of Agriculture, Forest Service, San Dimas Technology and Development Program. Pub. No. 7700. Washington, DC. 49 p.

National Research Council, Transportation Research Board. 1978. Geometric design standards for low-volume roads. Transportation Technology Support for Developing Countries Compendium 1. Washington, DC:

National Academy of Sciences. 297 p. (Compendium contains ten selected texts intended to provide useful documentation to those in developing countries concerned with the geometric design of low-volume roads).

Ochoa, M. Honduras LVR Reference

PIARC World Roads Association. 1994. International Road Maintenance Handbook-Practical Guidelines for Rural Road Maintenance. A Four Volume set published by Transport Research Laboratory, UK.

Strombom, R. 1987. Maintenance of aggregate and earth roads. Pub. No. WA-RD-144.1. Reprint 1994. Olympia, WA: Washington State Transportation Center. 72 p. [Online]. Available (one page summary): http://www.wsdot.wa.gov/ppsc/research/onepages/WA-RD1441.htm. [2000, July 30]. (Covers proper road maintenance techniques for unpaved roads.)

U.S. Department of Agriculture, Forest Service. 1999. Road analysis: Informing decisions about managing the national forest transportation system. Washington, DC. (Covers costs to maintain and mitigate in relationship to values at risk – uses and benefits as opposed to environmental damage.)

Weaver, W; Hagans. D. 1994. Handbook for Forest and Ranch Roads-A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining, and Closing Wildland Roads. By Pacific Watershed Associates for the Mendocino County Resource Conservation District, in cooperation with CDF and the NRCS. Ukiah, Calif.

Weist, R. 1998. A Landowner's Guide to Building Forest Access Roads. Report NA-TP-06-98. USDA, Forest Service, Northeastern Area, in cooperation with State and Private Forestry. Radnor, Pennsylvania. 45p.

Wildlands Solutions. 1999 Low Maintenance Roads Field Guide for Ranch, Fire, and Utility Access. Wildlands Solutions Field Guide Series, Clyde, Calif.

Hydrology for Drainage Crossing Design

McCuen, R.; Johnson, P.; Ragan, R. 1996. Highway Hydrology. Hydraulic Design Series No. 2. Pub. No. FHWA-SA-96-067. September. Washington, DC: U.S. Department of Transportation, Federal Highway Administration. 326 p. (Covers hydrologic techniques for methods suitable to small areas.)

Waananen, A.O.; Crippen, J.R. 1977. Magnitude and frequency of floods in California. Water resources investigation, 77-21. June. Reston, VA: U.S. Geologic Survey. 104 p. (Available through NTIS, Springfield, Va.)

Tools for Hydraulic Design: Manning's Formula, Riprap, Filters; and Use of Geosynthetics

Barnes, H. Jr. 1967. Roughness characteristics of natural channels. U.S. Geological Survey Water Supply Pap. 1849. Washington, D.C.: U.S. Government Printing Office.

Brown, S.A. 1986. Use of rip rap for bank protection: literature review report. Rep. No. SCR86-0002. McLean, VA: Department of Transportation, Federal Highway Administration, Office of Implementation. 114 p. (Involves a literature review to assess knowledge on the subject of stream bank protection as it relates to the design of riprap bank protection.)

Holtz, R.D.; Christopher, B.R.; Berg, R.R. 1998. Geosynthetic design and construction guidelines. Participant Notebook, NHI Course No. 13213 (Revised April1998). Rep. No. FHWA-HI-95-038. Washington DC: U.S. Department of Transportation, Federal Highway Administration. 484 p. (Covers the use and design of geotextiles, geogrids, and geocomposites in highway applications.)

Koerner, R. 1998. Designing with geosynthetics. 4th ed. Englewood Cliffs, NJ: Prentice Hall. 761p. (The only book of geosynthetics, this updated edition covers the latest materials and design techniques.)

Schall, J.D.; Richardson, E.V. 1997. Introduction to highway hydraulics. Hydraulic Design Series No. 4. Pub. No. FHWA-HI-97-028. June. Washington, DC: U.S. Department of Transportation, Federal Highway Administration. 209 p. (Covers hydrologic techniques for methods suitable to small areas.)

Brown, S.; Clyde, E. 1989. Design of Riprap Revetment. Hydraulic Engineering Circ. No. 11, March. Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

169 p. (Covers detailed design guidance for sizing and placing riprap.)

Steward, J.; Williamson, R.; Mohney, J. 1977. Guidelines for use of fabrics in construction and maintenance of low-volume roads. Interim Report. June. Portland, OR: U.S. Department of Agriculture, Forest Service, Region 6. 174 p. (Covers porous woven and non-woven fabrics used in road construction in Region 6 since 1974.)

U.S. Department of Agriculture, Natural Resources Conservation Service. 1994. Chapter 26 Gradation design of sand and gravel filters. In: Part 633, National Engineering Handbook. Washington, DC. 40 p.

General Considerations for Drainage of Rural Roads

Blinn, C.R.; Dahlman, R.; Hislop, L.; Thompson, M. 1998. Temporary stream and wetland crossing options for forest management. Forest Service Gen. Tech. Rep. NC-202. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 136 p. (Discusses temporary options for crossing streams and wetland soils with forest harvesting and t

Cedergren, H. 1977. Seepage, drainage, and flow nets. 3rd Ed. New York: John Wiley and Sons. 496 p.

Packer, P.; Christensen, G. 1964. Guide for Controlling Sediment from Secondary Logging Roads. USDA, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah (Government Printing Office 1980-682-866/222).

U.S. Department of Agriculture, Forest Service, Technology & Development Program. 1998. Water/road interaction: Introduction to surface cross drains. Water/Road Technology Series. September. Res. Rep. 9877 1806 – SDTDC. Washington, DC. (Covers surface and subsurface drainage, as well as drainage crossings.)

U.S. Department of Agriculture, Natural Resource Conservation Service. 1996. Streambank and shoreline protection. In: Engineering Field Handbook. December. Rep. No. NEH-650-16. Washington, DC. 130 p. (Covers bank protection from scour and erosion by using vegetative plantings, soil bioengineering, and structural systems.)

Zeedyk, W.D. 1996. Managing roads for wet meadow ecosystem recovery. November. Tech. Rep. FHWA-FLP-96-016. Albuquerque, NM: Department of Agriculture, Forest Service, Southwestern Region. 76 p.(Includes a riparian restoration guide for wet meadows.)

Culvert Use, Installation, and Sizing

American Iron and Steel Institute. 1994, Fifth Edition. Handbook of steel drainage and highway construction products. Washington, DC.

Normann, J.M.; Houghtalen, R.J.; Johnston, W.J. 1985. Hydraulic design of highway culverts. Hydraulic design series No. 5. Tech. Rep. No. FHWA-IP-86-15 HDS 5. September. McLean, VA: Department of Transportation, Federal Highway Administration, Office of Implementation. 265 p. (Includes a comprehensive design for both conventional culverts and culverts with inlet improvements.) [Online] Available: http://www.fhwa.dot.gov/bridge/hydpub.htm.

U.S. Department of Agriculture, Forest Service, Technology & Development Program. 1997. Relief culverts. Water/Road Technology Series. October. Washington, DC. (Covers surface and subsurface drainage, as well as drainage crossings.)

Fords and Low-Water Crossings

Berger, L.; Greenstein, J.; Arrieta, J. 1987. Guidelines for the design of low-cost water crossings. Transportation Res. Rec. 1106. Washington, DC: National Research Council, Transportation Research Board.

Coghlan, G.; Davis, N.; 1979. Low-water crossings. Transp. Res. Rec. 702, Washington, DC: National Research Council, Transportation Research Board.

Eriksson, M. 1983. Cost-effective low-volume-road stream crossings. Transp. Res. Rec. 898. Washington, DC: National Research Council, Transportation Research Board.

Motayed, A.K.; Chang, F.M.; Mukherjee, D.K.1982. Design and construction of low-water stream crossings. Executive summary. Tech. Rep. No. FHWA/RD-82/163. Washington, DC.: U.S. Department of Transportation, Federal Highway Administration. 129 p. (Literature on low-water stream crossings is reviewed and analyzed to develop a set of design criteria for such structures.)

Ring, S.L. 1987. The design of low-water stream crossings. Transportation Res. Rec. 1106. Washington, DC: National Research Council.

U.S. Department of Transportation, Transportation Research Board. 1979. Transportation Technology Support for Developing Countries -- Low-cost water crossings. Compendium 4, Prepared for U.S. Agency for International Development. Washington, DC. 203 p. (Provides useful information for those in deveoping countries who have direct responsibility for low-cost water crossings.)

Bridge Location and Design Factors

American Association of State and Transportation Officals. 1996. Standard specifications for highway bridges. Available: http://www.aashto.org [2000, July 30]. (Covers the design of wood, steel, and concrete bridges, as well as structural plate structures.)

Neill, C. Guide to bridge hydraulics. 1973. Toronto, ON: Project Committee on Bridge Hydraulics, Roads and Transportation Association of Canada.

Richardson, E.V.; Davis, S. R. 1995. Evaluating Scour at Bridges. Hydraulic Engineering Circular No. 18. Pub. No. FHWA-HI-96-031. November. Washington, DC: U.S. Department of Transportation, Federal Highway Administration. 204 p. (Covers all aspects of scour evaluation and determination of scour depth.)

Slope Stability and Stabilization of Cuts and Fills

Barrett, R.K. 1985. Geotextiles in earth reinforcement. Geotechnical Fabrics Rep., March/April:15-19.

Elias, V.; Christopher, B.R. Mechanically stabilized earth walls and reinforced soil slopes -- design and construction guidelines. 1997. August. Tech. Rep. No. FHWA-SA 96-071, reprinted September 1998. Washington, DC: Department of Transportation, Federal Highway Administration. 396 p. (Covers the design of mechanically stabilized earth walls and reinforced soil slopes.)

Gray, D.; Leiser, A. 1982. Biotechnical slope protection and erosion control. Melbourne, FL: Krieger Publishing Co. 288 p. (Covers various erosion control techniques, their design and construction.)

Gray, D.G.; Sotir, R.B. 1996. Biotechnical and soil bioengineering slope stabilization – A practical guide for erosion control. New York: John Wiley & Sons.

Holtz, R.D.; Christopher, B.R.; Berg, R.R. 1998. Geosynthetic design and construction guidelines. Participant Notebook, NHI Course No. 13213 (Revised April 1998). Tech. Rep. No. FHWA-HI-95-038. Washington DC: U.S. Department of Transportation, Federal Highway Administration. 484 p. (Covers the use and design of geotextiles, geogrids, and geocomposites in highway applications.)

Hoek, E.; Bray, J. 1974. Rock slope engineering. London: Institute of Mining and Metallurgy.

Keller, G.; Cummins, O. 1990. Tire retaining structures. Engineering Field Notes. 22:15-24, March/April Washington, DC: U.S. Department of Agriculture, Forest Service..

Mohney, J. Retaining wall design guide. 2d ed, 1994. Tech. Rep. No. EM-7170-14. Washington, DC: U.S. Department of Agriculture, Forest Service, Engineering Staff. Also, Pub. No. FHWA-FLP-94-006. September. Washington, DC: Department of Transportation, Federal Highway Administration, Federal Lands Highway Program. 537 p. [Online] http:www.ntis.gov. (Covers the analysis and design of a wide variety of retaining walls.)

Turner, A.K.; Schuster, R.L. 1996. Landslides -- investigation and mitigation. Tech. Rep. No. TRB-SR-247. Washington, DC: National Research Council, Transportation Research Board. 680 p. (Covers the analysis and design of unstable soil and rock slopes.)

Roadway Materials

ARRB Transport Research Ltd. 1996. Road dust control techniques – Evaluation of chemical dust suppressants' performance. Spec. Rep. 54. Victoria, Australia, [Online] http://www.arrb.org. (Covers the products available, how they work, selecting the product, and the product's environmental impacts.)

Bolander, P.; Yamada, A.1999. Dust Palliative Selection and Application Guide. November. U.S. Department of Agriculture, Forest Service, Technology & Development Program No. 9977 1207—SDTDC. Washington, DC. 19 p.

California Department of Conservation, Division of Mines and Geology. Fluvial geomorphology and river gravel mining: a guide for planners, case studies included. Special Publication 98.

Rodriguez, A; del Castillo, H; Sowers, G. F. 1988. Soil Mechanics in Highway Engineering. Federal Republic of Germany: TransTech Publications.

Scholen, D.E. 1992. Non-standard stabilizers. Pub. No. FHWA FLD-92-011. July. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Direct Federal Programs. (Covers the Forest Service use of various non-standard stabilization products.)

Sowers, G.F. 1979. Soil mechanics and foundations: Geotechnical engineering. 4th ed. New York: Macmillan.

U.S. Department of Agriculture, Forest Service. 1996. Earth and aggregate surfacing design guide for low-volume roads. September. Pub. No. EM-7170-16. Washington, DC. ## p. (Covers the design methodology for Surface Thickness Program, as well as an aid in selecting the type of surfacing and surface maintenance.)

Yamada, A. 1999. Asphalt seal coat treatments. April. U.S. Department of Agriculture, Forest Service, Technology & Development Program No. 9977 1201—SDTDC. Washington, DC. 24 p.

Yoder, E.J.; Witezak, M.M. 1975. Principles of Pavement Design. 2d ed. New York: John Wiley & Sons.

Erosion Control: Physical, Vegetative and Biotechnical Methods

Association of Bay Area Governments. 1995. Manual of standards for erosion & sediment control measures. May. 2d ed. San Fransisco, CA. 500 p. (A comprehensive field guide for controlling soil erosion in California).

Burroughs, E.; King, J. 1989. Reduction of soil erosion on forest roads. Tech. Rep. No. FSGTR-INT-264, July. Moscow, ID: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 26 p. (Covers expected reduction in surface erosion from selected treatments applied to forest road traveled ways, cutslopes, fillslopes, and ditches.)

Gray, D.; Leiser, A. 1982. Biotechnical slope protection and erosion control. Melbourne, FL: Krieger Publishing Co. 288 p. (Covers various erosion control techniques, their design and construction.)

Grimshaw, R.G.; Helfer, L. (eds.). 1995. Vetiver grass for soil and water conservation, land rehabilitation, and embankment stabilization: a collection of papers and newsletters compiled by the vetiver network. World Bank Technical Pap. No. 273. Washington, DC.: The World Bank. 288 p. (A collection of papers and newsletters supporting the use of vetiver grass conservation as a low-cost biological system of erosion control and water conservation.)

U.S. Department of Agriculture, Soil Conservation Service. 1992. Soil bioengineering for upland slope protection and erosion reduction (Part 650). Ch. 18. In: Engineering field handbook. October. Washington, DC. 62 p. (Covers various erosion control techniques, their design and construction.)

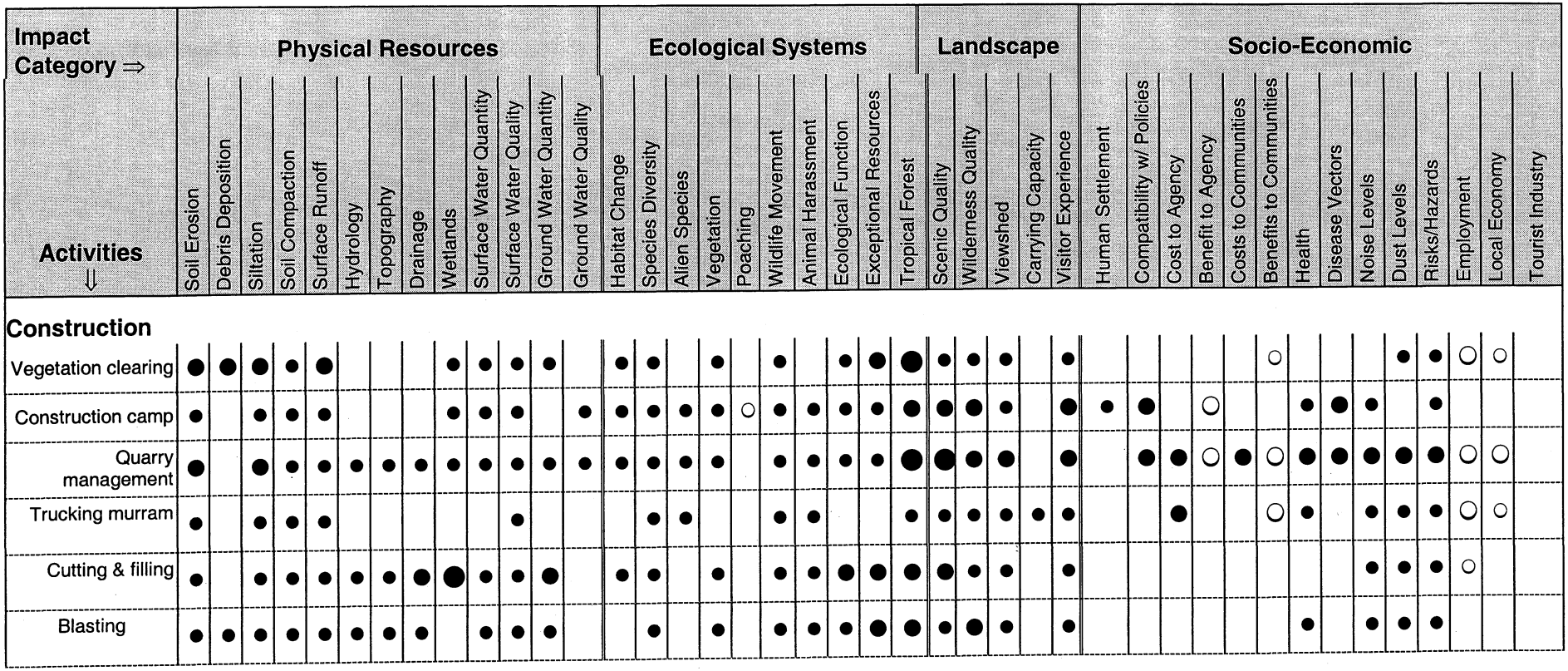
Stabilization of Gullies

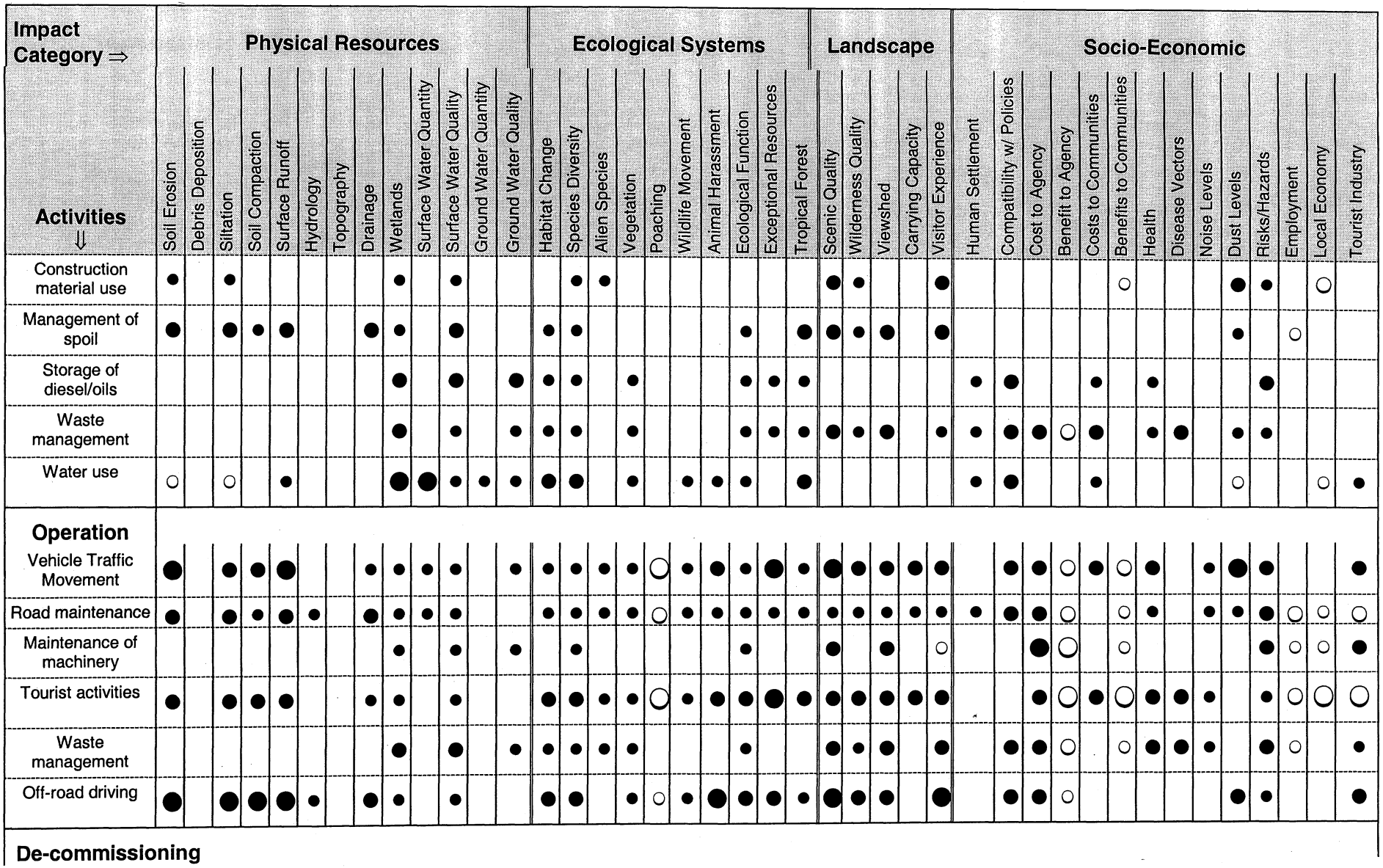
Gray, D.; Leiser, A. 1982. Biotechnical slope protection and erosion control. Melbourne, FL: Krieger Publishing Co. 288 p. (Covers various erosion control techniques, their design and construction.)

Sample Road Improvements Environmental Impact Matrix

Legend

Adverse Impact Level		Beneficial Impact Level
●	Low	○
●	Medium	○
●	High	○




Impact Category ⇒
Physical Resources
Ecological Systems
Landscape
Socio-Economic
Activities ⇓
Soil Erosion
Debris Deposition
Siltation
Soil Compaction
Surface Runoff
Hydrology
Topography
Drainage
Wetlands
Surface Water Quantity
Surface Water Quality
Ground Water Quantity
Ground Water Quality
Habitat Change
Species Diversity
Alien Species
Vegetation
Poaching
Wildlife Movement
Animal Harassment
Ecological Function
Exceptional Resources
Tropical Forest
Scenic Quality
Wilderness Quality
Viewshed
Carrying Capacity
Visitor Experience
Human Settlement
Compatibility w/ Policies
Cost to Agency
Benefit to Agency
Costs to Communities
Benefits to Communities
Health
Disease Vectors
Noise Levels
Dust Levels
Risks/Hazards
Employment
Local Economy
Tourist Industry
Construction material use
Management of spoil
Storage of diesel/oils
Waste management
Water use
Operation
Vehicle Traffic Movement
Road maintenance
Maintenance of machinery
Tourist activities
Waste management
Off-road driving
De-commissioning

Impact Category ⇒	Physical Resources													Ecological Systems									Landscape					Socio-Economic												
Activities ⇓	Soil Erosion	Debris Deposition	Siltation	Soil Compaction	Surface Runoff	Hydrology	Topography	Drainage	Wetlands	Surface Water Quantity	Surface Water Quality	Ground Water Quantity	Ground Water Quality	Habitat Change	Species Diversity	Alien Species	Vegetation	Poaching	Wildlife Movement	Animal Harassment	Ecological Function	Exceptional Resources	Tropical Forest	Scenic Quality	Wilderness Quality	Viewshed	Carrying Capacity	Visitor Experience	Human Settlement	Compatibility w/ Policies	Cost to Agency	Benefit to Agency	Costs to Communities	Benefits to Communities	Health	Disease Vectors	Noise Levels	Dust Levels	Risks/Hazards	Employment	Local Economy	Tourist Industry
Ripping old road	●		●		○			○	●	○	●	○			●						●			○	●	●					●	○								
Shaping	○		○	●	○		○	○	○	○	●			○	●		○				●		○	○	○	○		○			●	○				○		●	○		
Revegetation	○		○		○	○		○	○	○	○	○		○	●		○				●		○	○	○	○		○			●	○				○			○		

SITE DESCRIPTION AND INFORMATION SURVEY

This Site Description and Information Survey Form is intended to assist you in obtaining and recording information regarding the project site. This survey should be conducted with a site map in hand. This form will help you describe the site as well as identify potential risk areas and environmental sensitive areas. This form has been developed as a checklist to help prompt you to identify important information that is needed for developing a TESC plan. Much of the information may be obtained while still in the office but it is essential to verify all information in the field. ***Each of the following categories of information should be identified and assessed.***

Project Information

Name of Project: _____

Date: _____

Recent Weather Conditions: _____

Soil Type: Check the soil type (or combination of types) that best describes the soil found on site, or give the soil classification (if known). Describe the soil, if necessary.

❑ Gravel ❑ Gravelly Sands/Sandy Gravels ❑ Sand ❑ Silty Sands/Sandy Silts

❑ Silt ❑ Clay ❑ Peat

Soil Classification (if known): _____

Jar Test Results: _____

Slope Stability: _____

Infiltration Area: _____

Topography: Area Wide Topography: _____

General Site Basin or Slope Direction: _____

Cut and Fill Slopes: _____

Other: _____

Drainage Features: Check the drainage features that are on site. Describe if necessary:

Existing Runoff (ditches, streams): _____

Runoff from impervious surfaces: _____

Temporary conveyances: _____

Final conveyances: _____

Surface: Describe the surfaces on the site (paved, gravel, vegetated). Note locations of paved/unpaved areas and approximate sizes (if applicable) on your site map.
❑ Gravel/Soil ❑ Vegetated/Undeveloped ❑ Capped/Paved (asphalt/concrete)

_____

_____

_____

Adjacent Properties:

Potential impacts from upgradient properties: _____

Potential impacts to downgradient properties: _____

Groundwater:

Record the depth to groundwater (if known), or depth at which groundwater is expected to be encountered.

Depth to groundwater (known or suspected): _____

Seeps and springs: _____

Low areas with seasonal flooding or high water table: _____

Surface Water Bodies: Check all surface water bodies that are on site or adjacent to the site. Describe if necessary.

❑ Lakes, ponds
❑ Rivers, streams, creeks
❑ Wetlands, swamp
❑ None
❑ Other_____

_____

_____

_____

_____

Table 2.5
Site Erosion Risk Checklist

Inherent Level of Risk Associated with a Site	Low	Medium	High	Comments
Soil-related risks				
How erodible is the soil?				
What is the potential for slides?				
What is the expected turbidity from exposed areas?				
Would detention NOT remove sediment from runoff?				
Do soils lend to high or low runoff volumes?				
What is the potential for dust problems?				
What level of effort would be needed to reestablish vegetation?				
Weather				
Total rainfall?				
Intensity of rainfall events?				
Probability of rainfall?				
Probability of rain on snow events?				
Intensity/frequency of erosive winds?				
Topography				
Size, gradient and stability of slopes in work area?				
Size, gradient and stability of slopes above or below the work area?				
What is the potential to trap and treat runoff in natural depressions of flat vegetated areas?				
Flowing Water?				
Likelihood that surface runoff could cause concentrated flows?				
Likelihood that runoff from impervious surfaces could damage grades and/or water quality?				
How difficult would it be to intercept and divert runoff from impervious surfaces?				
Likelihood of potentially damaging offsite runoff flowing into the construction area?				
How difficult would it be to intercept and divert offsite runoff?				
Potential of offsite water overwhelming detention facilities and conveyances?				
Probability of water damaging conveyances?				
Groundwater				
Probability of intercepting potentially damaging groundwater seeps and springs?				
Potential of groundwater impacting detention areas and pond effectiveness that would delay construction, and reduce BMP effectiveness?				
Potential for slope failures due to groundwater seeps?				
Probability of encountering a seasonal high water table?				
Level of difficulty to de-water?				
Probability of budget problems and cost overruns due to groundwater?				
Sensitive Areas				
Likelihood that runoff could impact to State waters (streams or wetlands)?				
Likelihood that runoff could impact ESA listed fish?				
Potential for damage to adjacent properties?				
Potential for impacts from other neighboring construction projects (trackout, poor BMPs)?				

Table 3.4
Physical Control BMP Selection Guide Based on Potential Problems

#	POTENTIAL PROBLEM SITUATION (Reminder: all erosion BMPs help prevent sediment problems)	RECOMMENDED BMPS
1	Erosion due to rainfall on exposed soils	Preserving Vegetation, Track Walking, Straw, Mulching & Matting, PAM, Temporary Seeding, Hydroseed/Mulch spray mixture, Bonded Fiber Matrix, Plastic, Sodding, Topsoiling, Permanent Seeding and Planting
2	Erosion due to rainfall on short or low gradient exposed slopes	Preserving Vegetation, Track Walking, Straw, Mulching & Matting, PAM, Temporary Seeding, Hydroseed/Mulch spray mixture, Bonded Fiber Matrix, Plastic, Sodding, Topsoiling, Permanent Seeding and Planting
3	Erosion due to long or steep exposed slopes	Preserving Vegetation, Track Walking, Gradient Terraces, Straw, Mulching & Matting, PAM, Temporary Seeding, Hydroseed/Mulch spray mixture, Bonded Fiber Matrix, Plastic, Sodding, Topsoiling, Permanent Seeding and Planting Conveyance – Interceptor Dike and Swale, Pipe Slope Drains
4	Erosion due to concentrated runoff from impervious surfaces flowing onto exposed slopes	Interceptor Dike and Swale, Pipe Slope Drains
5	Erosion due to offsite water running onto exposed slopes as either concentrated flow or sheet runoff	Pipe Slope Drains, Interceptor Dike and Swale
6	Erosion in ditches due to high velocity flows	Check Dams, Sodding, Matting, Rip-Rap Channel Lining, Level Spreader
7	Sediment-laded water leaving the site as sheet flow	Filter Fence, Straw Bale Barrier, Brush Barrier, Gravel Filter Berm
8	Sediment–laden water entering the storm drain	Storm Drain Inlet Protection and New Products, Stabilized Construction Entrance & Tire Wash, Construction Road Stabilization, Early First Asphalt Lift or Gravel Bedding in Areas to be Paved
9	Sediment-laden water leaving the site as concentrated flow	Sediment Trap, Temporary Sediment Pond, Outlet Protection, Chemical Stormwater Treatment
10	Tracking of sediment onto roadways	Stabilized Construction Entrance & Tire Wash, Street Sweeper, Early First Asphalt Lift or Gravel Bedding in areas to be paved, Maintenance of Construction Entrance
11	Discharges of concentrated, high velocity flows causing erosion	Level Spreader, Temporary Sediment Pond, Outlet Protection

[a] When a variety of alternative BMPs can be used to solve a particular problem, refer to the Highway Runoff Manual and Ecology's Stormwater Management Manual for guidance to select the preferred BMP.

PART 1 OF THE SCOPING CHECKLIST: QUESTIONS ON PROJECT CHARACTERISTICS

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1. Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality (topography, land use, changes in waterbodies, etc)?				
1.1	Permanent or temporary change in land use, landcover or topography including increases in intensity of land use?			
1.2	Clearance of existing land, vegetation and buildings?			
1.3	Creation of new land uses?			
1.4	Pre-construction investigations eg boreholes, soil testing?			
1.5	Construction works?			
1.6	Demolition works?			
1.7	Temporary sites used for construction works or housing of construction workers?			
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations?			
1.9	Underground works including mining or tunnelling?			
1.10	Reclamation works?			
1.11	Dredging?			
1.12	Coastal structures *eg* seawalls, piers?			
1.13	Offshore structures?			
1.14	Production and manufacturing processes?			
1.15	Facilities for storage of goods or materials?			
1.16	Facilities for treatment or disposal of solid wastes or liquid effluents?			
1.17	Facilities for long term housing of operational workers?			

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1.18	New road, rail or sea traffic during construction or operation?			
1.19	New road, rail, air, waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?			
1.20	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?			
1.21	New or diverted transmission lines or pipelines?			
1.22	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?			
1.23	Stream crossings?			
1.24	Abstraction or transfers of water from ground or surface waters?			
1.25	Changes in waterbodies or the land surface affecting drainage or run-off?			
1.26	Transport of personnel or materials for construction, operation or decommissioning?			
1.27	Long term dismantling or decommissioning or restoration works?			
1.28	Ongoing activity during decommissioning which could have an impact on the environment?			
1.29	Influx of people to an area in either temporarily or permanently?			
1.30	Introduction of alien species?			
1.31	Loss of native species or genetic diversity?			
1.32	Any other actions?			
2. Will construction or operation of the Project use natural resources such as land, water, materials or energy, especially any resources which are non-renewable or in short supply?				
2.1	Land especially undeveloped or agricultural land?			
2.2	Water?			
2.3	Minerals?			

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
2.4	Aggregates?			
2.5	Forests and timber?			
2.6	Energy including electricity and fuels?			
2.7	Any other resources?			
3. Will the Project involve use, storage, transport, handling or production of substances or materials which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health?				
3.1	Will the project involve use of substances or materials which are hazardous or toxic to human health or the environment (flora, fauna, water supplies)?			
3.2	Will the project result in changes in occurrence of disease or affect disease vectors (eg insect or water borne diseases)?			
3.3	Will the project affect the welfare of people eg by changing living conditions?			
3.4	Are there especially vulnerable groups of people who could be affected by the project eg hospital patients, the elderly?			
3.5	Any other causes?			
4. Will the Project produce solid wastes during construction or operation or decommissioning?				
4.1	Spoil, overburden or mine wastes?			
4.2	Municipal waste (household and or commercial wastes)?			
4.3	Hazardous or toxic wastes (including radioactive wastes)?			
4.4	Other industrial process wastes?			
4.5	Surplus product?			
4.6	Sewage sludge or other sludges from effluent treatment?			
4.7	Construction or demolition wastes?			
4.8	Redundant machinery or equipment?			

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
4.9	Contaminated soils or other material?			
4.10	Agricultural wastes?			
4.11	Any other solid wastes?			
5. Will the Project release pollutants or any hazardous, toxic or noxious substances to air?				
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources?			
5.2	Emissions from production processes?			
5.3	Emissions from materials handling including storage or transport?			
5.4	Emissions from construction activities including plant and equipment?			
5.5	Dust or odours from handling of materials including construction materials, sewage and waste?			
5.6	Emissions from incineration of waste?			
5.7	Emissions from burning of waste in open air (*eg* slash material, construction debris)?			
5.8	Emissions from any other sources?			
6. Will the Project cause noise and vibration or release of light, heat energy or electromagnetic radiation?				
6.1	From operation of equipment eg engines, ventilation plant, crushers?			
6.2	From industrial or similar processes?			
6.3	From construction or demolition?			
6.4	From blasting or piling?			
6.5	From construction or operational traffic?			
6.6	From lighting or cooling systems?			

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
6.7	From sources of electromagnetic radiation (consider effects on nearby sensitive equipment as well as people)?			
6.8	From any other sources?			
7. Will the Project lead to risks of contamination of land or water from releases of pollutants onto the ground or into sewers, surface waters, groundwater, coastal waters or the sea?				
7.1	From handling, storage, use or spillage of hazardous or toxic materials?			
7.2	From discharge of sewage or other effluents (whether treated or untreated) to water or the land?			
7.3	By deposition of pollutants emitted to air, onto the land or into water?			
7.4	From any other sources?			
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?			
8. Will there be any risk of accidents during construction or operation of the Project which could affect human health or the environment?				
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous or toxic substances?			
8.2	From events beyond the limits of normal environmental protection eg failure of pollution control systems?			
8.3	From any other causes?			
8.4	Could the project be affected by natural disasters causing environmental damage (*eg* floods, earthquakes, landslip, *etc*)?			
9. Will the Project result in social changes, for example, in demography, traditional lifestyles, employment?				
9.1	Changes in population size, age, structure, social groups *etc*?			
9.2	By resettlement of people or demolition of homes or communities or community facilities eg schools, hospitals, social facilities?			
9.3	Through in-migration of new residents or creation of new communities?			
9.4	By placing increased demands on local facilities or services eg housing, education, health?			
9.5	By creating jobs during construction or operation or causing the loss of jobs with effects on unemployment and the economy?			
9.6	Any other causes?			

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
Question - Are there any other factors which should be considered such as consequential development which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality?				
9.1	Will the project lead to pressure for consequential development which could have significant impact on the environment eg more housing, new roads, new supporting industries or utilities, etc?			
9.2	Will the project lead to development of supporting facilities, ancillary development or development stimulated by the project which could have impact on the environment eg: • supporting infrastructure (roads, power supply, waste or waste water treatment, etc) • housing development • extractive industries • supply industries • other?			
9.3	Will the project lead to after-use of the site which could have an impact on the environment?			
9.4	Will the project set a precedent for later developments?			
9.5	Will the project have cumulative effects due to proximity to other existing or planned projects with similar effects?			

PART 2 OF THE SCOPING CHECKLIST: CHARACTERISTICS OF THE PROJECT ENVIRONMENT

For each project characteristic identified in Part consider whether any of the following environmental components could be affected.

Question - Are there features of the local environment on or around the Project location which could be affected by the Project?
• Areas which are protected under international or national or local legislation for their ecological, landscape, cultural or other value, which could be affected by the project?
• Other areas which are important or sensitive for reasons of their ecology e.g.
  • Wetlands,
  • Watercourses or other waterbodies,
  • the coastal zone,
  • mountains,
  • forests or woodlands
• Areas used by protected, important or sensitive species of fauna or flora e.g. for breeding, nesting, foraging, resting, overwintering, migration, which could be affected by the project?
• Inland, coastal, marine or underground waters?
• Areas or features of high landscape or scenic value?
• Routes or facilities used by the public for access to recreation or other facilities?
• Transport routes which are susceptible to congestion or which cause environmental problems?
• Areas or features of historic or cultural importance?

Question - Is the Project in a location where it is likely to be highly visible to many people?
Question - Is the Project located in a previously undeveloped area where there will be loss of greenfield land?
Question - Are there existing land uses on or around the Project location which could be affected by the Project? For example: • Homes, gardens, other private property, • Industry, • Commerce, • Recreation, • public open space, • community facilities, • agriculture, • forestry, • tourism, • mining or quarrying
Question - Are there any plans for future land uses on or around the location which could be affected by the Project?
Question - Are there any areas on or around the location which are densely populated or built-up, which could be affected by the Project?
Question - Are there any areas on or around the location which are occupied by sensitive land uses which could be affected by the Project? • hospitals, • schools, • places of worship, • community facilities
Question - Are there any areas on or around the location which contain important, high quality or scarce resources which could be affected by the Project? For example: • groundwater resources, • surface waters, • forestry, • agriculture, • fisheries, • tourism, • minerals.
Question - Are there any areas on or around the location of the Project which are already subject to pollution or environmental damage e.g. where existing legal environmental standards are exceeded, which could be affected by the project?

Question - Is the Project location susceptible to earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions e.g. temperature inversions, fogs, severe winds, which could cause the project to present environmental problems?
Question - Is the Project likely to affect the physical condition of any environmental media? • The atmospheric environment including microclimate and local and larger scale climatic conditions? • Water - eg quantities, flows or levels of rivers, lakes, groundwater. Estuaries, coastal waters or the sea? • Soils - eg quantities, depths, humidity, stability or erdodibility of soils? • Geological and ground conditions?
Question - Are releases from the Project likely to have effects on the quality of any environmental media? • Local air quality? • Global air quality including climate change and ozone depletion • Water quality – rivers, lakes, groundwater. Estuaries, coastal waters or the sea? • Nutrient status and eutrophication of waters? • Acidification of soils or waters? • Soils • Noise? • Temperature, light or electromagnetic radiation including electrical interference? • Productivity of natural or agricultural systems?
Question - Is the Project likely to affect the availability or scarcity of any resources either locally or globally? • Fossil fuels? • Water? • Minerals and aggregates? • Timber? • Other non-renewable resources? • Infrastructure capacity in the locality - water, sewerage, power generation and transmission, telecommunications, waste disposal roads, rail?
Question - Is the Project likely to affect human or community health or welfare? • The quality or toxicity of air, water, foodstuffs and other products consumed by humans? • Morbidity or mortality of individuals, communities or populations by exposure to pollution? • Occurrence or distribution of disease vectors including insects? • Vulnerability of individuals, communities or populations to disease? • Individuals' sense of personal security? • Community cohesion and identity? • Cultural identity and associations? • Minority rights? • Housing conditions? • Employment and quality of employment? • Economic conditions? • Social institutions?

CHECKLIST OF CRITERIA FOR EVALUATING THE SIGNIFICANCE OF IMPACTS

Instructions for Scoping

This checklist is designed to help users decide whether or not an impact is likely to be significant and is to be used in conjunction with the Scoping Checklist.

The Scoping Checklist provides a list of questions to help identify where there is the potential for interactions between a project and its environment. This checklist is designed to help decide whether those interactions - effects - are likely to be significant.

Those responsible for scoping often find difficulties in defining what is "significant". A useful simple check is to ask whether the effect is one that ought to be considered and to have an influence on the development consent decision. At the early stages of a project there is likely to be little information on which to base this decision but the following list of questions may be helpful.

The questions to be asked are the same as in Screening but at the Scoping stage it is important to provide as much information as possible on why the effect is considered likely to be significant, rather than a simple "yes/no" answer.

Questions to be Considered

1. Will there be a large change in environmental conditions?
2. Will new features be out-of-scale with the existing environment?
3. Will the effect be unusual in the area or particularly complex?
4. Will the effect extend over a large area?
5. Will there be any potential for transfrontier impact?
6. Will many people be affected?
7. Will many receptors of other types (fauna and flora, businesses, facilities) be affected?
8. Will valuable or scarce features or resources be affected?
9. Is there a risk that environmental standards will be breached?
10. Is there a risk that protected sites, areas, features will be affected?
11. Is there a high probability of the effect occurring?
12. Will the effect continue for a long time?
13. Will the effect be permanent rather than temporary?
14. Will the impact be continuous rather than intermittent?
15. If it is intermittent will it be frequent rather than rare?
16. Will the impact be irreversible?
17. Will it be difficult to avoid, or reduce or repair or compensate for the effect?

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HSE
Health & Safety Executive

Construction health and safety checklist

Construction Sheet No 17 (revised)

This checklist identifies some of the hazards most commonly found on construction sites. The questions it asks are intended to help you decide whether your site is a safe and healthy place to work. **It is not an exhaustive list.** More detailed information can be found in HSG150 *Health and safety in construction* and other HSE publications.

Safe places of work

- Can everyone reach their place of work safely, eg are roads, gangways, passageways, passenger hoists, staircases, ladders and scaffolds in good condition?
- Are there guard rails or equivalent protection to stop falls from open edges on scaffolds, mobile elevating work platforms, buildings, gangways, excavations, etc?
- Are holes and openings securely guard railed, provided with an equivalent standard of edge protection or provided with fixed, clearly marked covers to prevent falls?
- Are structures stable, adequately braced and not overloaded?
- Are all working areas and walkways level and free from obstructions such as stored material and waste?
- Is the site tidy, and are materials stored safely?
- Are there proper arrangements for collecting and disposing of waste materials?
- Is the work adequately lit? Is sufficient additional lighting provided when work is carried on after dark or inside buildings?

Scaffolds

- Are scaffolds erected, altered and dismantled by competent persons?
- Is there safe access to the scaffold platform?
- Are all uprights provided with base plates (and, where necessary, timber sole plates) or prevented in some other way from slipping or sinking?
- Are all the uprights, ledgers, braces and struts in position?
- Is the scaffold secured to the building or structure in enough places to prevent collapse?
- Are there adequate guard rails and toe boards or an equivalent standard of protection at every edge from which a person could fall 2 m or more?
- Where guard rails and toe boards or similar are used:
  - are the toe boards at least 150 mm in height?
  - is the upper guard rail positioned at a height of at least 910 mm above the work area?
  - are additional precautions, eg intermediate guard rails or brick guards in place to ensure that there is no unprotected gap of more than 470 mm between the toe board and upper guard rail?
- Are the working platforms fully boarded and are the boards arranged to avoid tipping or tripping?
- Are there effective barriers or warning notices in place to stop people using an incomplete scaffold, eg where working platforms are not fully boarded?
- Has the scaffold been designed and constructed to cope with the materials stored on it and are these distributed evenly?
- Does a competent person inspect the scaffold regularly, eg at least once a week; always after it has been substantially altered, damaged and following extreme weather?
- Are the results of inspections recorded?

Powered access equipment

- Has the equipment been erected by a competent person?
- Is fixed equipment, eg mast climbers, rigidly connected to the structure against which it is operating?
- Does the working platform have adequate guard rails and toe boards or other barriers to prevent people and materials falling off?
- Have precautions been taken to prevent people being struck by the moving platform, projections from the building or falling materials, eg barrier or fence around the base?
- Are the operators trained and competent?
- Is the power supply isolated and the equipment secured at the end of the working day?

Ladders

- Are ladders the right means of access for the job?
- Are all ladders in good condition?
- Are they secured to prevent them slipping sideways or outwards?
- Do ladders rise a sufficient height above their landing place? If not, are there other hand-holds available?
- Are the ladders positioned so that users don't have to over-stretch or climb over obstacles to work?
- Does the ladder rest against a solid surface and not on fragile or insecure materials?

Roof work

- Are there enough barriers and is there other edge protection to stop people or materials falling from roofs?
- Do the roof battens provide safe hand and foot holds? If not, are crawling ladders or boards provided and used?
- During industrial roofing, are precautions taken to stop people falling from the leading edge of the roof or from fragile or partially fixed sheets which could give way?
- Are suitable barriers, guard rails or covers, etc provided where people pass or work near fragile material such as asbestos cement sheets and roof lights?
- Are crawling boards provided where work on fragile materials cannot be avoided?
- Are people excluded from the area below the roof work? If this is not possible, have additional precautions been taken to stop debris falling onto them?

Excavations

- Is an adequate supply of timber, trench sheets, props or other supporting material made available before excavation work begins?
- Is this material strong enough to support the sides?
- Is a safe method used for putting in the support, ie one that does not rely on people working within an unsupported trench?
- If the sides of the excavation are sloped back or battered, is the angle of batter sufficient to prevent collapse?
- Is there safe access to the excavation, eg by a sufficiently long, secured ladder?
- Are there guard rails or other equivalent protection to stop people falling in?
- Are properly secured stop blocks provided to prevent tipping vehicles falling in?
- Does the excavation affect the stability of neighbouring structures?
- Are materials, spoil or plant stored away from the edge of the excavation in order to reduce the likelihood of a collapse of the side?
- Is the excavation inspected by a competent person at the start of every shift; and after any accidental collapse or event likely to have affected its stability?

Manual handling

- Has the risk of manual handling injuries been assessed?
- Are hoists, telehandlers, wheel-barrows and other plant or equipment used so that manual lifting and handling of heavy objects is kept to a minimum?
- Are materials such as cement ordered in 25 kg bags?
- Can the handling of heavy blocks be avoided?

Hoists

- Is the hoist protected by a substantial enclosure to prevent someone from being struck by any moving part of the hoist or falling down the hoistway?
- Are gates provided at all landings, including ground level?
- Are the gates kept shut except when the platform is at the landing?
- Are the controls arranged so that the hoist can be operated from one position only?
- Is the hoist operator trained and competent?
- Is the hoist's safe working load clearly marked?
- If the hoist is for materials only, is there a warning notice on the platform or cage to stop people riding on it?
- Is the hoist inspected weekly, and thoroughly examined every six months by a competent person?
- Are the results of inspection recorded?

Cranes and lifting appliances

- Is the crane on a firm level base?
- Are the safe working loads and corresponding radii known and considered before any lifting begins?

- If the crane has a capacity of more than 1 tonne, does it have an automatic safe load indicator that is maintained and inspected weekly?
- Are all operators trained and competent?
- Has the banksman/slinger been trained to give signals and to attach loads correctly?
- Do the operator and banksman find out the weight and centre of gravity of the load before trying to lift it?
- Are cranes inspected weekly, and thoroughly examined every 14 months by a competent person?
- Are the results of inspections and examinations recorded?
- Does the crane have a current test certificate?

Plant and machinery

- Is the right plant and machinery being used for the job?
- Are all dangerous parts guarded, eg exposed gears, chain drives, projecting engine shafts?
- Are guards secured and in good repair?
- Is the machinery maintained in good repair and are all safety devices operating correctly?
- Are all operators trained and competent?

Traffic and vehicles

- Have separate pedestrian, vehicle access points and routes around the site been provided? If not, are vehicles and pedestrians kept separate wherever possible?
- Have one-way systems or turning points been provided to minimise the need for reversing?
- Where vehicles have to reverse, are they controlled by properly trained banksmen?
- Are vehicles maintained; do the steering, handbrake and footbrake work properly?
- Have drivers received proper training?
- Are vehicles securely loaded?
- Are passengers prevented from riding in dangerous positions?

Fire and emergencies

General

- Have emergency procedures been developed, eg evacuating the site in case of fire or rescue from a confined space?
- Are people on site aware of the procedures?
- Is there a means of raising the alarm and does it work?
- Are there adequate escape routes and are these kept clear?

Fire

- Is the quantity of flammable material on site kept to a minimum?
- Are there proper storage areas for flammable liquids and gases, eg LPG and acetylene?
- Are containers and cylinders returned to these stores at the end of the shift?
- If liquids are transferred from their original containers are the new containers suitable for flammable materials?
- Is smoking banned in areas where gases or flammable liquids are stored and used? Are other ignition sources also prohibited?
- Are gas cylinders and associated equipment in good condition?
- When gas cylinders are not in use, are the valves fully closed?
- Are cylinders stored outside?
- Are adequate bins or skips provided for storing waste?
- Is flammable and combustible waste removed regularly?
- Are the right number and type of fire extinguishers available and accessible?

Hazardous substances

- Have all harmful materials, eg asbestos, lead, solvents, paints etc been identified?
- Have the risks to everyone who might be exposed to these substances been assessed?
- Have precautions been identified and put in place, eg is protective equipment provided and used; are workers and others who are not protected kept away from exposure?

Noise

- Are breakers and other plant or machinery fitted with silencers?
- Are barriers erected to reduce the spread of noise?
- Is work sequenced to minimise the number of people exposed to noise?
- Are others not involved in the work kept away?

- Is suitable hearing protection provided and worn in noisy areas?

Welfare

- Have suitable and sufficient numbers of toilets been provided and are they kept clean?
- Are there clean wash basins, warm water, soap and towels?
- Is suitable clothing provided for those who have to work in wet, dirty or otherwise adverse conditions?
- Are there facilities for changing, drying and storing clothes?
- Is drinking water provided?
- Is there a site hut or other accommodation where workers can sit, make tea and prepare food?
- Is there adequate first aid provision?
- Are welfare facilities easily and safely accessible to all who need to use them?

Protective clothing

- Has adequate personal protective equipment, eg hard hats, safety boots, gloves, goggles, and dust masks been provided?
- Is the equipment in good condition and worn by all who need it?

Electricity

- Is the supply voltage for tools and equipment the lowest necessary for the job (could battery operated tools and reduced voltage systems, eg 110 V, or even lower in wet conditions, be used)?
- Where mains voltage has to be used, are trip devices, eg residual current devices (RCDs) provided for all equipment?
- Are RCDs protected from damage, dust and dampness and checked daily by users?
- Are cables and leads protected from damage by sheathing, protective enclosures or by positioning away from causes of damage?
- Are all connections to the system properly made and are suitable plugs used?
- Is there an appropriate system of user checks, formal visual examinations by site managers and combined inspection and test by competent persons for all tools and equipment?
- Are scaffolders, roofers, etc, or cranes or other plant, working near or under overhead lines? Has the electricity supply been turned off, or have other precautions, such as 'goal posts' or taped markers been provided to prevent them contacting the lines?
- Have underground electricity cables been located (with a cable locator and cable plans), marked, and precautions for safe digging been taken?

Protecting the public

- Are the public fenced off or otherwise protected from the work?
- When work has stopped for the day:
  - are the gates secured?
  - is the perimeter fencing secure and undamaged?
  - are all ladders removed or their rungs boarded so that they cannot be used?
  - are excavations and openings securely covered or fenced off?
  - is all plant immobilised to prevent unauthorised use?
  - are bricks and materials safely stacked?
  - are flammable or dangerous substances locked away in secure storage places?

Reference

HSG150: *Health and safety in construction* HSE Books 1996 ISBN 0 7176 1143 4

HSE priced and free publications are available by mail order from:

HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA
Tel: 01787 881165; Fax: 01787 313995. HSE priced publications are available from good booksellers.

For other enquiries ring HSE's InfoLine, tel: 0541 545500, or write to HSE's Information Centre, Broad Lane, Sheffield S3 7HQ.

HSE home page on the World Wide Web:
http://www.open.gov.uk/hse/hsehome.htm

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

Trade Contractor Quality Control

by Ed Caldeira, NAHB Research Center

When you have quality problems, do you shop for a new trade contractor that will make your problems go away? Do all the replacement candidates tell you the familiar "we're reliable and do quality work"? Is it the same pitch you heard last year from the trade contractor that you're firing?

Certainly some trade contractors do better than others. But it seems that no matter how many of the poor performers are weeded out, the average quality performance doesn't seem to rise very much.

As surely as you'll have a few new trade contractors next year, you can also be sure that you will have more quality problems and you'll start looking around again.

As the saying goes "if you always do what you do, you'll always get what you got." Changing trade contractors is doing what you always do. Why should you expect overall quality to get better? Improving quality is more than finding new ways to hire and fire trade contractors.

We need to change the approach to quality control. First, we need to know how a trade contractor quality control system should work. To find out, the NAHB Research Center analyzed quality control issues in residential construction, identified areas where the current system needed improvement, and determined how they can be improved. The study concluded that effective quality controls must operate within the trade contractor's work crews to prevent problems before they occur. To accomplish this, the quality control system should set requirements for approved materials, use of qualified persons to perform specific tasks, work standards, explicit sales contracts, and jobsite inspection by the crews performing the work.

ISO 9000, the internationally recognized quality control standard integrates these elements into a comprehensive system. On the basis of ISO 9000, the Research Center developed a Trade Contractor Quality Control Manual (see sidebar).

Builders can use the Trade Contractor Quality Control Manual as a model to help their trade contractors bring good quality control practices to their crews. This

involves training contractors on the approach, helping them to adapt the Manual to their trades, and making sure that it applies to existing quality problem areas.

To test this approach, the Research Center adapted the quality manual to the insulation trade. This involved obtaining all of the manufacturer's installation standards, developing an insulation inspection checklist and training contractors in the quality control system. Three insulation contractors participated in an pilot program sponsored by CertainTeed. This program produced positive results, and a second program for External Insulation and Finish System (EIFS) Installers has been designed and is in the pilot testing phase.

Assessing compliance to the quality control requirements is straightforward. The first step is to verify the paper trail of contracts, jobsite inspections, use of approved materials, and records of qualified installers. The next step involves detailed jobsite audits to observe workmanship, use of materials, and quality control procedures. The Research Center uses these procedures in a new program to independently certify the quality controls of insulation contractors. Currently over 65 contractors are certified.

Next time you have a quality problem with a trade contractor don't just change your contractor, change your contractor's quality controls!

Trade Contractor Quality Control Guidelines

The NAHB Research Center's Trade Contractor Quality Control Manual sets requirements that enable trade contractors to address key elements of a quality control system. The manual provides a general approach that is to be tailored to each trade.

Qualified Materials and Installation Procedures

Materials and the designed use of materials are critical elements of quality installations. To prevent confusion regarding what materials are to be used and how, a list is made of acceptable materials, acceptable installation methods, and any requirements for special equipment.

Qualified Installers

Installer capabilities are critical to every quality installation. Trade contractors may set their own standards and methods for evaluating the installers' skill, knowledge, and workmanship or recognize a trade skills certification program. When all requirements are met, trade contractors keep lists of installers qualified to perform various installation tasks. Helpers may assist on the jobsite, although quality responsibility remains with the qualified installer.

Sales Contracts

Sales contracts must clearly describe the work to be performed. The contracts are used as the basis for an agreement with the builder, and by installation crews for work instructions. The contracts consist of two parts. The first part, Installation Requirements, defines the responsibilities of the builder and of other trade contractors necessary for a high performance, durable installation.

The second part of the sales contracts is called the Scope of Work. It contains the specifications for installation work to be performed by the trade contractor.

Jobsite Inspections

The preceding sections describe the foundation for quality controls on the jobsite. Jobsite inspections involve checklists specific to each trade to verify that approved materials are used according to the installation instructions, that qualified installers perform the work, and that the Scope of Work requirements are met.

Each inspection checklist should address key quality control checkpoints and quality problem areas specific to the trade. Quality inspections should use checklists at each work phase to verify that:

- architectural design requirements and building conditions are suitable for installation;
- previous work phases are complete;
- work was performed by qualified personnel;
- only approved materials were used;
- The amount of materials used was sufficient to complete the work phase;
- Scope of Work requirements have been met;
- installation specifications and procedures have been met;
- the work phase is complete; and
- any quality problems have been corrected.

Quality System Audits

Periodic audits assess whether the system is effective at controlling quality, and whether the contractor is conforming to the requirements of the Trade Contractor Quality Manual. The audits involve periodic reviews of installation crew performance, and of the overall quality system. They can be performed by the trade contractor, builder, or a third party auditor.

Quality questions? Looking for specifications? Call the ToolBase Hotline (800)898-2842.

The NAHB Research Center is the not-for-profit research arm of the National Association of Home Builders, and is located in Upper Marlboro, MD. In its nearly 40 years of service to the home building industry, the Research Center has provided product research and building process improvements that have been widely adopted by home builders in the United States. Through testing and certification services, the NAHB Research Center seal is recognized throughout the world as a mark of product quality and an assurance of product performance.

NOTE TO EDITORS ON STYLE USAGE: In order to correctly identify this company and its work, first reference should be "NAHB Research Center." If clarification of the acronym is necessary, the phrase, "a subsidiary of the National Association of Home Builders (NAHB)," can follow. In subsequent mentions, "Research Center" is the only acceptable and accurate alternative reference.

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Inspection Checklists for Trade Contractors

by Ed Caldeira, NAHB Research Center

A properly designed inspection checklist form can demonstrate due diligence in complying with regulations, manufacturer's instructions, and workmanship standards. You can use it to set expectations for what needs to go right, and once completed it can serve as a record of what actually happened.

The trade contractor's crew supervisor should use an inspection checklist to perform inspections on every job. If the trade has several phases of work on a home, prepare a separate inspection form for each one. In addition, the builder can use a copy of the same forms while performing quality reviews.

ISO 9000, the internationally recognized quality control standard, sets requirements necessary to assure conformance to specifications. The ISO 9000 approach not only assures that specifications are met but also confirms that all the elements of a reliable construction process are in place.

Jobsite Installation Record provides basic information about job location, start date, and the type of product or system that is to be installed.

Job Readiness questions verify there are no adverse conditions that impact quality and the job is suitable for work to begin. This should include availability of installation instructions and adequacy of work performed by previous trades, as well as building or environmental conditions that can affect quality.

Use of Materials should be documented. When materials affect quality, the inspection form should capture specific information on primary as well as secondary materials when they make a difference to the completed job.

Installation Inspection questions verify that product manufacturer's specifications are followed and that workmanship meets expectations. Examine manufacturer's installation instructions, NER product evaluation reports, codes, and regulations to identify key requirements that need to be followed for performance and durability. Supplement this with provisions for the needs of the following trades and your own expectations. Whenever inspection questions verify conformance to dimensional specifications, actual

measurements should be recorded. Also verify the use of specific equipment or tools if they affect quality results.

Problems Found should be recorded, even if they are corrected. When the problem results in a deviation from specifications, note the deviation.

Job Complete sign-off should be done by the responsible craftsman after verifying satisfaction with workmanship and that the work is complete to specification. List any remaining repair items to be completed.

I encourage you to collaborate with your trade contractors and product manufacturers to prepare inspection checklists for each of your trades. The jobsite inspection checklist is an important element of a builder's quality control system to help you build problem-free, durable homes.

A sample "Trade Contractor Inspection Checklist" and answers to your quality questions are free by calling the NAHB Research Center's ToolBase Hotline ***(800) 898-2842****. Visit the quality pages at http://www.nahbrc.org.*

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